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The Impact of Trade and Technology on Skills in Viet Nam

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Market-oriented reforms, such as liberalizing trade and encouraging foreign direct investment, can generate large efficiency gains for a country. However, there is also concern that lower-skilled workers are increasingly being replaced by technology and that more globalized markets are harming employment opportunities. This paper investigates these important issues by exploring household surveys from Viet Nam, combined with information on the task content of occupations, industrial exposure to international trade, and access to technology across the country. We assess the extent to which exposure to foreign markets and access to digital technologies affect the demand for different types of skills, by exploiting the fact that provinces vary in the degree of access to digital technologies and industries vary in the degree of exposure to foreign markets. In our work, we also extend much of the literature to consider the interplay between trade and technology on labor demand. On its own, technological change does not appear to be a main driver of the demand for skill in Viet Nam. Increased trade, rather, does expand employment opportunities across both skilled and unskilled workers. Consistent with classic trade theory, the increase is stronger for manual and routine tasks, shifting the composition of the labor force toward lower-skilled workers. However, the increase in manual and routine employment opportunities in response to the trade shock is smaller in areas of the country with access to digital technologies, providing suggestive evidence of the routine-biased nature of technology. From a policy standpoint, our work contributes to an understanding of job requirements and job security in an increasingly technology-driven and integrated world economy. Our research also offers insights for other lesser developing countries that face similar challenges.

Keywords
Viet Nam, trade, information technology, skills

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Abstract

Market-oriented reforms, such as liberalizing trade and encouraging foreign direct investment, can generate large efficiency gains for a country. However, there is also concern that lower-skilled workers are increasingly being replaced by technology and that more globalized markets are harming employment opportunities. This paper investigates these important issues by exploring household surveys from Viet Nam, combined with information on the task content of occupations, industrial exposure to international trade, and access to technology across the country. We assess the extent to which exposure to foreign markets and access to digital technologies affect the demand for different types of skills, by exploiting the fact that provinces vary in the degree of access to digital technologies and industries vary in the degree of exposure to foreign markets. In our work, we also extend much of the literature to consider the interplay between trade and technology on labor demand. On its own, technological change does not appear to be a main driver of the demand for skill in Viet Nam. Increased trade, rather, does expand employment opportunities across both skilled and unskilled workers. Consistent with classic trade theory, the increase is stronger for manual and routine tasks, shifting the composition of the labor force toward lower-skilled workers. However, the increase in manual and routine employment opportunities in response to the trade shock is smaller in areas of the country with access to digital technologies, providing suggestive evidence of the routine-biased nature of technology. From a policy standpoint, our work contributes to an understanding of job requirements and job security in an increasingly technology-driven and integrated world economy. Our research also offers insights for other lesser developing countries that face similar challenges.

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1. INTRODUCTION

Key market-oriented reforms, such as trade liberalization and encouraging foreign direct investment, have fundamentally changed the nature and organization of productive activities across countries, sectors, and firms. One of the key arguments in favor of such liberalizing policies is the reallocation of factors of production—workers and machinery—to their most efficient use. Meanwhile, the rapid development of communication technologies and the automation of production processes have made it possible for firms, sectors, and countries to accentuate the fragmentation of the value chain in order to benefit from the efficiency gains associated with international trade. Together, trade and technology offer the possibility for income and employment growth. At the same time, there is also a growing concern that technology is replacing routine, codifiable jobs, harming employment opportunities for lower-skilled workers.

Our work investigates these important issues by exploring household surveys from Viet Nam, combined with data on the task content of occupations, on industry-level exposure to international trade, and on provincial-level variation in access to information and communications technology. We assess the extent to which the adoption of digital technology and increased exposure to foreign markets affects the demand for different types of skills in the labor market. Our work also extends much of the existing literature to consider the interplay between trade and technology on labor demand. As trade can be a conduit for technological advancement and communications technology can serve to lower trade costs, we hypothesize that the two economic forces have a compounding effect on the demand for skills. From a policy standpoint, our work contributes to an understanding of job requirements and job security in an increasingly technology-driven and integrated world economy. Our research also offers insights for other lesser developed countries facing similar challenges.

Viet Nam's reforms under the "Doi Moi" renovation plan, launched in 1986, formally shifted the economy toward a new economic strategy, based on integration in the global economy, export diversification, and attraction of foreign direct investment. Based on this strategy, Viet Nam has become one of the most open economies in Asia with rapid economic growth and a strong poverty reduction. Meanwhile, the demand for skilled workers in the country has markedly increased.

We investigate the relationship between trade, technology, and skills—a key objective of the country's national development plan—relying on data from the Viet Nam Household Living Standard Surveys (VHLSS) between 2002 and 2012, a period of significant internet service expansion, particularly in the Northern provinces. We match these household surveys to industry-level information on international trade from the United Nations Conference on Trade and Development's (UNCTAD) COMTRADE database. Our main outcome of interest explores local (industry-province-time) variation in the demand for cognitive and manual tasks, as well as non-routine and routine skills (as identified by occupations). As our main trade variable may be endogenous due to industry-specific shocks to productivity that increase Vietnamese exports and the skill-intensity of the workforce, we follow previous work and instrument industry-specific exports from Viet Nam with the world's demand for imports in the same industry and year. Our work considers the level effects of trade and technology—defined as the share of households with access to internet services in the province—as well as their interaction.

Our main results suggest that, on its own, digital technologies do not seem to influence the demand for skills in Viet Nam. By contrast, industries that face an exogenous shock to exports, through increased world import demand of their goods, experience increases in employment opportunities, across all types of tasks—manual, cognitive, non-routine, and routine. In addition, consistent with classic trade theory for a relatively low-skilled labor abundant country like Viet Nam, the increase in manual and routine (low skilled) tasks is relatively larger, shifting the composition of the local labor market toward low-skill employment.

However, as trade helps to spread technology and lower communication costs associated with technology promote trade, we also find that trade impacts industries differently depending on whether they are located in technologically advanced areas of the country. Otherwise identical industries, facing similar exogenous shocks to foreign market exposure, demonstrate relatively smaller increases in employment opportunities if they are located in provinces with stronger access to the internet. Moreover, this effect is fully driven by a relative decrease in manual and routine tasks, suggesting that trade may enhanced the skill-biased nature of technology. Future research intends to explore the gender dimension of this increased globalization—as an important development outcome.

The rest of this paper is organized as follows. Section 2 offers some background on Viet Nam's main economic reforms, setting the stage for an expansion in international trade and technology. In Section 3, we provide a review of the existing literature on trade and technology, paying special attention to research focused on developing countries and Viet Nam, in particular. In Section 4, we present our main data and detail some descriptive statistics alongside. Section 5 presents our main reduced-form empirical model and Section 6 describes our main results. We offer conclusions and policy implications in the final section.

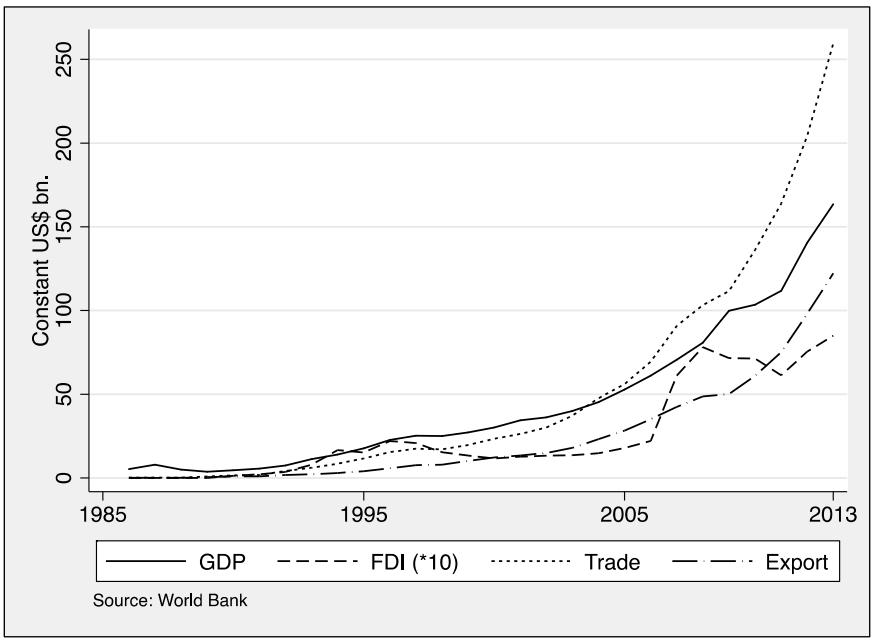
2. BACKGROUND

In this section, we outline the major economic policy reforms in Viet Nam over the last half-century, which contributed to rising trade and an expansion of digital technologies.

2.1 Policy Reforms and Openness

Viet Nam launched important reforms under the "Doi Moi" renovation plan in 1986. The plan formally shifted the economy toward a new economic strategy, based on integration in global markets, export diversification, and attraction of foreign direct investment (FDI). Figure 1 depicts the remarkable growth in trade and foreign investment in Viet Nam since 1985, and the corresponding growth in income. The open economy approach evolved jointly with national development strategies centered on agricultural development, light industrialization, and a continued role for state-owned enterprises, meanwhile encouraging growth of the private sector (Thoburn 2013).

Figure 1: Trade and Foreign Direct Investment in Viet Nam

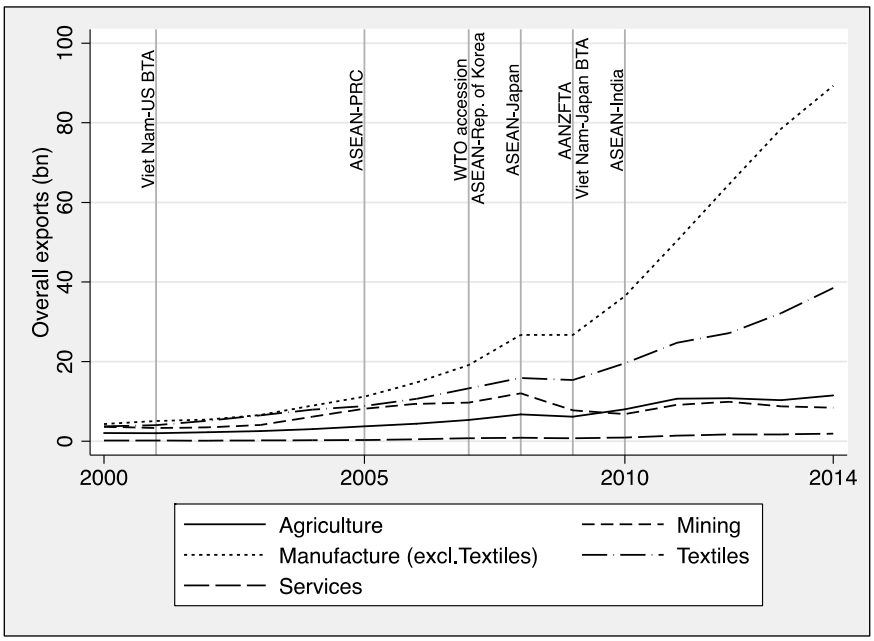


FDI = foreign direct investment, GDP = gross domestic product.
Source: World Bank, World Development Indicators (2016).

Following the Doi Moi, Viet Nam has become one of the most open economies in Asia. In the mid-1990s, the country advanced its regional integration strategy by joining regional agreements such as the Association of Southeast Asian Nations (ASEAN) and the Asia-Pacific Economic Cooperation (APEC) group. The signing of the US-Viet Nam bilateral trade agreement (BTA) in 2001 and the accession to the World Trade Organization (WTO) in 2007 helped to drive economic success. Following the BTA, the immediate drop in tariffs on Vietnamese exports substantially lowered the cost of exporting to the US (McCaig 2011; McCaig and Pavcnik 2013), contributing to the expansion of Viet Nam's exports, notably in the manufacturing and textiles industries, as is depicted in Figure 2.

Trade expansion and rapid economic growth allowed Viet Nam to transition from one of the world's poorest countries to a lower-middle income economy. Gross domestic product per capita increased from US$100 in 1985 to US$2,100 in 2015. The country also experienced a substantial reduction in the number of people living in poverty, as is evidenced by the data in Figure 3. Prior to the reforms, Viet Nam was predominantly an agrarian economy and self-employed farmers represented a major share of the labor force. Innovative changes in agricultural production fueled the growth of the wage employment sector (McCaig and Pavcnik 2013). The relative increase in the price of exported commodities, in addition to the government programs to reduce poverty amongst disadvantaged groups, contributed to poverty reduction (Heo and Doanh 2009).

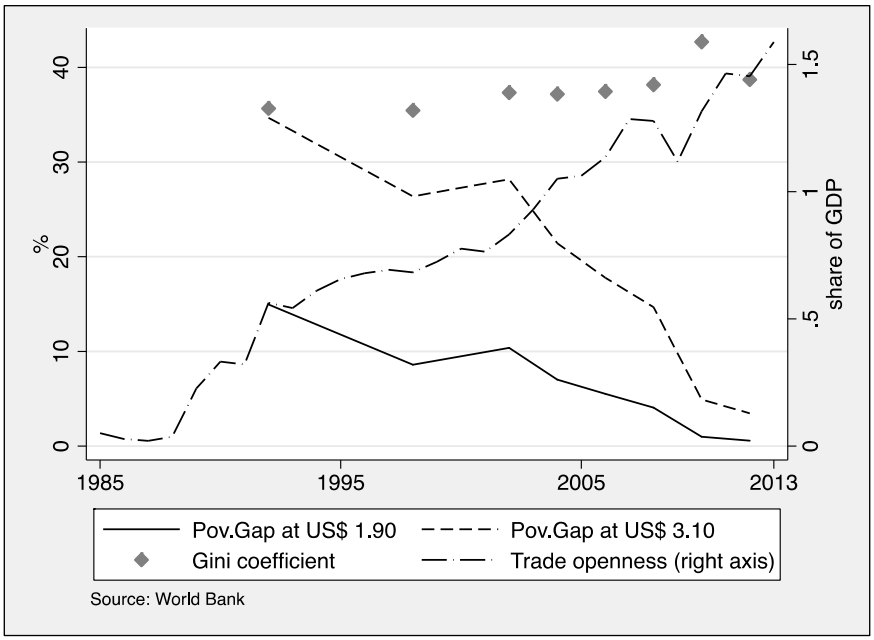
Figure 2: Evolution of Viet Nam's Exports, by Major Industry Group (2000–2015)



AANZFTA = ASEAN–Australia–New Zealand Free Trade Agreement, BTA = Bilateral Trade Agreement, PRC = People's Republic of China.

Source: UNCTAD, UNStat-Comtrade Statistics.

Figure 3: Trade Openness, Poverty, and Inequality in Viet Nam



GDP = gross domestic product, Pov. = poverty.

Source: World Bank, World Development Indicators (2016).

Despite high growth rates and poverty reduction, gains have not spread homogenously. Consequently, increases in income inequality between and within regions of the country have transpired. Structural transformation from agriculture to manufacturing is heterogenous by region and this likely contributes to unequal growth in Viet Nam (Sarma et al. 2017). Moreover, the observed increases in inequality in incomes and opportunities can be potentially explained by changing patterns of employment—specifically, employment shifting away from agriculture and away from lower-skill to higher-skill and higher productivity non-farm jobs (IMF 2016).[1] Such changes are on average reflected in the Gini coefficient, which rose from 36 in 1992 to 43 in 2010. This is qualitatively small in comparison to other middle-income countries in East Asia, though there is still an income gap between rural and urban areas, and across demographic groups. A wage bias is also still observed in favor of public sector employees (World Bank 2014).

In terms of the questions set out in this paper, more recently, both the ASEAN economic integration agreement and Viet Nam's national development plan emphasize skills development for modern industry and innovation and the role of technology and trade for achieving these development goals. Despite impressive basic literacy and numeracy achievements, there is still a skill shortage in the job market. For instance, numerous firms report a shortage of workers with the necessary technical skills. Also, firms are increasingly demanding cognitive skills, such as problem-solving and critical thinking, as well as behavioral skills in non-manual tasks (World Bank 2014).

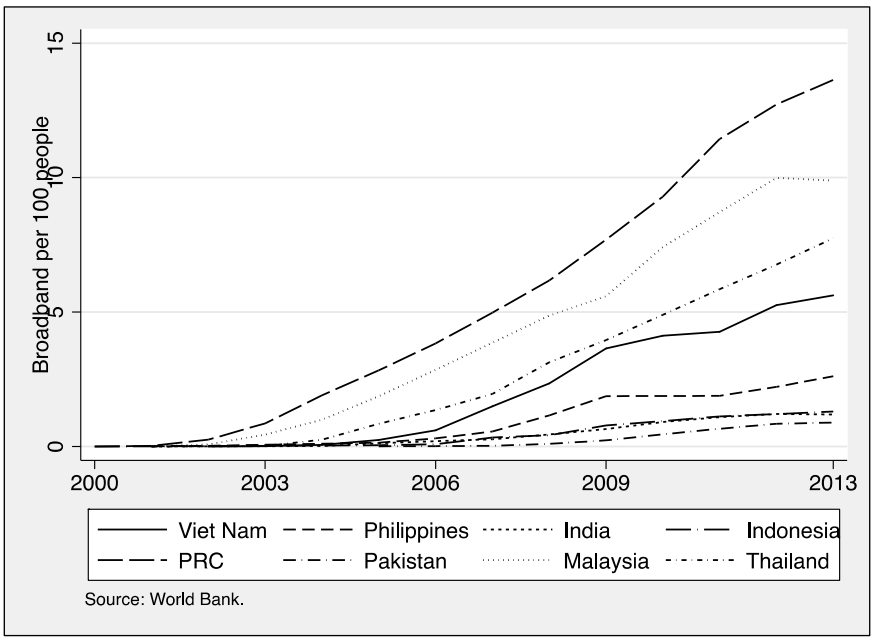
2.2 Technology Adoption

The innovation of the internet is one of the most critical technological advancements of the 20th century, affecting economic and social development. Internet connection was first legalized in Viet Nam in March 1997 under Degree 21/CP (Lam, et al. 2004). By December 2002, the Viet Nam Internet Network Information Center (VNNIC) reported 195,245 subscribers, reflecting only 0.25% of the population. The main reasons for this low internet penetration are correlated with several explanatory factors including limited technological infrastructure (including access to computers) and high internet access costs, which represent a substantial share of annual earnings per capita in a developing country like Viet Nam.

However, more recently, the share of the population with a personal computer has been rising. The country currently ranks just behind Malaysia and the People's Republic of China in Asia in terms of access to computers (WDI 2016). All provinces have seen a modest increase in computer ownership, though the Northern provinces still lag behind. Computer ownership levels do not accurately reflect the overall level of computer use in Viet Nam. We argue internet access serves as a better variable to access technological change, as it accounts for usage from computers at work or home. In fact, Viet Nam has seen a steady increase in access to the internet, with the most pronounced increases in the Northern provinces. Figure 4 depicts the increase internet demand, as shown by fixed broadband subscriptions per 100 people, between 2000 and 2013.

[1] Rising income inequality in Viet Nam may also be partly attributable to a highly localized ethnic composition. The ethnic majority group, the Kinhs, is concentrated in regions that are experiencing the most modern sector activity (Sarma, et al. 2017).

Figure 4: Internet Connectivity in Asia



PRC = People's Republic of China.

Source: World Bank, World Development Indicators (2016).

3. LITERATURE REVIEW

In this section, we review the literature on the impact of technology on employment in the developed and developing world, as well as the relevant research on trade, employment, and technology in Viet Nam. We are not aware of many papers that address the interaction between trade and technology as in our paper.

3.1 Technology, Trade, and Employment

The role of technology in reshaping the global workforce is a topic of constant discussion (Autor, Levy, and Murnane 2003; Acemoglu and Restrepo 2017). Digital technologies affect jobs, labor productivity, and consumer welfare through trade. Although the role of trade as a channel for the diffusion of technology across borders is recognized (Keller 2004), research on the interplay between trade and technology on employment and the demand for tasks is still scarce.

Technology

A large body of research has tried to disentangle the effects of trade and automation technology on employment, particularly in advanced economies since the 1990s. While the direction and magnitude of employment changes in non-routine tasks varies between countries, the pattern with regard to middle-skilled routine jobs is consistent, displaying a distinct decline of routine jobs, leading to job polarization and growing wage disparities. Existing research suggests that technological change in the current globalization wave is skill-biased. There exists a strong link between the automation of tasks associated with technology and the relative decrease of routine tasks (Berman, et al. 1994; Autor, Levy, and Murnane 2003).

The seminal work by Autor, Levy, and Murnane (2003) argues that computers substitute for workers carrying out routine-manual or routine-cognitive tasks, and complement workers involved in non-routine analytic and interactive tasks.[2] For the case of the US in the 1990s, research documents that the widening wage gap can be largely attributed to stronger increases in the demand for highly educated workers. The increase in relative demand is driven by skill-biased technological change, largely associated with the spread of computers and microprocessor-based technologies in the workplace (Berman, et al. 1994; Autor, et al. 1998). According to Autor, et al. (1998), the diffusion of computers and related technologies, and the resulting changes in the organization of work concomitant with effectively utilizing such technologies, contributed to the observed rapid within-industry skill upgrading of the workforce.

Digital technologies are also expanding rapidly in developing countries, but the impact on employment and wages is less studied. Almeida, Corseuil, and Poole (2017) assess the link between access to the internet and the demand for skills in the largest Latin American country—Brazil. The estimates suggest that digital technology adoption leads to a reduction in employment in local labor markets, and more so for routine tasks. By contrast, Hjort and Poulson (2016) analyze the impact of fast internet arrival on labor market outcomes for African countries, and point to a positive effect of technology on employment.

Trade

A substantive body of research shows that trade affects the labor market. Increased exposure to global markets impacts wages and employment (Artuç, et al. 2010), occupational composition (Ebenstein, et al. 2014), and regions where industries locate (Autor, et al. 2013, and 2015). Autor, et al. (2015) show that competition from the People's Republic of China has had a negative impact on workers in competing sectors in the US, and employment shortfalls are particularly large among workers without college education. Cortes, Jaimovich, and Sui (2016) analyze the tradeoff between unemployment and non-employment among those workers particularly susceptible to import competition. They find that many redundant workers in routine jobs are forced to accept non-routine manual occupations and many others move into non-employment, providing an explanation for the sharp decline in labor force participation in recent years in the US.

The shifts in employment opportunities in response to rising globalization has implications for wage inequality (Harrison, et al. 2011; Goldberg and Pavcnik 2007; Topalova 2010). In developed countries, wage inequality increased coincident with trade and globalization as predicted by the factors proportions, Heckscher–Ohlin, classic trade theory. Counter to classic trade theory, wage inequality also increased in developing countries (Goldberg and Pavcnik 2007). Research argues the growing wage disparities can be explained by non-trade related factors, like skill-driven technological change.

Lower trade barriers allow firms to disintegrate the production process and offshore some production tasks (Blinder 2009). Because routine tasks are more easily codifiable, they are seen as more likely to be moved abroad in contrast with non-routine tasks (Levy and Murnane 2004; Leamer and Storper 2001). This reorganization of the production process allows firms to become more productive (Grossman and Rossi-Hansberg 2008). Thus, lower trade costs may lead to a simultaneous growth in productivity and trade, and offers an ambiguous effect on employment. On the one

[2] Routine tasks are activities that can be readily computerized because they follow precise, well-defined procedures (Autor and Dorn 2013).

hand, tasks may be offshored, while on the other hand, efficiency gains allow for an expansion of output, and potentially employment. Ebenstein, Harrison, and McMillan (2014) report that offshoring to the People's Republic of China by US multinational firms had a negative impact on US labor force participation. However, the authors also comment that increasing computer use and the substitution of capital for labor are significantly more important determinants of US employment rates across occupations.

Technology and Trade

There is little research that considers the interaction between international trade and technological change. Some work, relying on enterprise surveys, shows a shift toward exporting with increased technology. For example, Bustos (2011) studies the decisions of firms regarding skill composition, technology upgrading, and exporting. Exporters are more likely to adopt technology and to upgrade the skill level of the workforce (see also Kugler and Verhoogen 2012). Brambilla et al. (2012) show that the wage skill premium is significantly higher in exporting firms. However, the link between trade, foreign investment, and skill-biased technology has been difficult to document empirically (Pavcnik 2002).

3.2 Technology, Trade, and Employment in Viet Nam

Evidence on the impact of digital technology on jobs and welfare has not been widely explored for Viet Nam. Meanwhile, there is substantial evidence that Viet Nam's pro-market trade reforms have helped to significantly reduce poverty and increase formal labor market employment.

Technology

The demand for educated, skilled labor is associated with recent technological developments that are contributing to a rising skill premium (Sakellarious and Patrinos 2003). The information technology (IT) sector is one industry that has received high levels of foreign involvement in Viet Nam. It is an attractive destination due to relatively low wages and operating costs (Shillabeer 2013), combined with a young workforce with increasing technological and scientific skills, as well as a high percentage of English speakers (Thangvelu 2013). The impact of increased information technology investment has relatively benefited Viet Nam's younger population who see the opportunity for relatively high wages and heightened social status of working for an international company (Shillabeer 2013).

Sakellariou and Patrinos (2003) study the impact of computer use on wages in Viet Nam, as well as the determinants of computer use. Higher-educated workers experience larger average annual wage increases with computer use when compared to lower-skilled workers, supporting growing wage inequality. Konstadakopulous (2005) studies the characteristics of firms adopting technology and assesses whether adoption leads increased regional cooperation. The study finds that significant levels of information and communications technology penetration are limited to export-oriented sectors based in more urban areas where internet connection is higher.

Trade

Heo and Doanh (2009) argue that trade liberalization has been a key factor in poverty reduction in Viet Nam, mostly through the employment channel, due to the labor-intensive nature of exports. Kien and Heo (2009) investigate the impact of trade liberalization on employment in Viet Nam between 1999 and 2004. The paper indicates a positive impact of export expansion on labor demand, implying that the higher level of exports resulted in employment opportunities for the country's large labor surplus. Interestingly, the empirical estimates show that imports did not negatively affect Viet Nam's employment level.

A more recent literature explores the effects of trade reforms by analyzing regional variations in exposure to trade. McCaig (2011) documents the substantial increase in Viet Nam's exports to the US following the BTA, which granted Viet Nam Most-Favored-Nation status in US markets. The paper constructs measures of exposure to US tariff cuts using variation in the structure of the labor force across provinces before the trade agreement. The empirical results show that provinces more exposed to tariff cuts experienced faster decreases in poverty between 2002 and 2004. In follow-up work, McCaig and Pavcnik (2013) examine the consequences of these increased export opportunities on the economy-wide reallocation of labor across industries and across firms within industries. The study reveals a decline in employment in household businesses following the implementation of the agreement. A large portion of this fall is driven by labor reallocation to larger, more formal firms within industries, which in turn experienced relatively larger increases in exporting opportunities.

Consistent with McCaig and Pavcnik (2013), Fukase (2013) finds that the BTA induced labor reallocation towards Viet Nam's comparative advantage sectors. The paper also analyses the impact of the BTA on wage levels of skilled and unskilled workers and the skill premium, and constructs an export index at the province level isolating the effects of the US tariff cuts on wages from the impacts of the domestic reforms. The main findings show that provinces that were more exposed to US tariff cuts experienced faster wage growth for workers with low levels of education, but not for the highly educated.

Technology and Trade

Technological developments and increased exports each alone cannot explain the increasing wage inequality in Viet Nam. The opening of trade, complemented by high-tech capital investment and a transition to higher value-added activities, had a positive effect on the wage share of skilled workers (Thangvelu 2013). This is reflected in the import of intermediate inputs like machines and equipment that caused skill-biased technological change in Vietnamese firms and thus increased wage inequality between skilled and unskilled workers. This piece of evidence supports the idea that trade liberalizing policies increased technological progress in Viet Nam that is skill-biased. Our paper also explores this idea in the context of the demand for skills.

4. DATA

We build panel data for province-industry observations. There are several main sources of data in the paper. Data on employment and access to internet technology comes from the Viet Nam Household Living Standards Survey (VHLSS), while the industry trade data comes from UNStat Comtrade and UNCTAD TRAINS. Finally, the task content of occupations is based on the U.S. Department of Labor's Occupational Information Network (O*NET) database.

4.1 Household Data

We use six waves of the VHLSS—biannually from 2002 to 2012. The surveys are conducted based on the World Bank's Living Standard Measurement Surveys (LSMS). Survey samples are representative at the national level and are stratified geographically. The survey is conducted for households from the 63 provinces, which comprise eight geographical regions of the country. Every survey wave consists of questions asked about the household in general, and individual members of the household.

Employment

We use individual member survey information on the main occupation and industry of the employed person. The individual's occupation is defined by the most time-consuming job reported in the survey and the individual's industry is defined by the main product and industry code of the salaried employment. The occupational classification used in the VHLSS survey is the International Standard Classification of Occupations (ISCO) from 1988 and 2008 depending on the survey year. We use official concordance tables to match the ISCO-08 occupations into ISCO-88 occupations for a time-consistent classification of occupations. The industrial classification in the VHLSS follows the International Standard Industrial Classification (ISIC), with increasing disaggregation over time. For a time-consistent classification of industries, we use the aggregate 2-digit ISIC Revision 3 as the benchmark classification, similar to McCaig (2011).

Occupational Task Content

The US Department of Labor surveys workers in all occupations about the skills required for the occupation and the activities performed in the occupation. These occupation-specific attributes are maintained in the Department of Labor's Occupational Information Network (O*NET). Our paper utilizes this information from the year 2000 for approximately 800 occupations in the US Standard Occupational Classification (SOC). O*NET offers "importance scores" ranging between 1 and 5 for 52 different "abilities" and 41 different "activities" associated with an occupation. A score of 1 means that a given attribute is "Not Important" to the occupation, while a score of 5 means that a given attribute is "Extremely Important" to the occupation. Our main assumption in using data from the US is that the same skills and activities are required in similar occupations in Viet Nam. Even if the levels of such abilities and activities may be different across the two countries, we argue that the ranking of the importance of such tasks in similar occupations will not drastically differ. For this reason, we rely on O*NET's importance scores of different abilities and activities in U.S. occupations to characterize abilities and activities in Vietnamese occupations.

In order to better interpret O*NET's ordinal importance score ranking across occupations, we standardize the scores into a normalized numerical index between 0 and 1, which relies on each occupation's share of employment in the pre-period year of 1999—data which we calculated using Viet Nam's 1999 Decennial Census. The normalization allows us to speak to the relative importance of such a skill among Vietnamese workers. For instance, a score of 0.05 suggests that only 5% of employed workers supply this skill less intensively, whereas a score of 0.95 suggests that few workers supply the skill more intensively.

Our interest in this paper is in how technology, trade, and their interaction impact routine, manual skills as compared to non-routine, cognitive skills; that is, our interest is in broader skill groupings than those described in the raw O*NET database. Therefore, we next aggregate across abilities and activities within a "bundle" for each occupation. We consider the following ability bundles: manual and cognitive. Table 4.1 displays our classification of the 52 O*NET abilities into these distinct categories. We also consider the following activity bundles: routine versus non-routine activities. Table 4.2 displays our classification of the 41 O*NET activities into these distinct bundles.

The final step in generating our main dependent variable is to aggregate across all workers employed in a province and industry in each survey year.

Table 4.1: O*NET Abilities Classification

Manual Tasks		Cognitive Tasks	
Precision	**Other**	**Analytical**	**Communication**
Arm-Hand	Reaction Time	Fluency of Ideas	Oral Comprehension
Steadiness	Wrist-Finger Speed	Originality	Written
Manual Dexterity	Speed of Limb	Problem Sensitivity	Comprehension
Finger Dexterity	Movement	Deductive Reasoning	Oral Expression
Control Precision	Static Strength	Inductive Reasoning	Written Expression
Multilimb	Explosive Strength	Information Ordering	Speech Recognition
Coordination	Dynamic Strength	Category Flexibility	Speech Clarity
Response	Trunk Strength	Mathematical	
Orientation	Stamina	Reasoning	
Rate Control	Extent Flexibility	Number Facility	
	Dynamic Flexibility	Memorization	
	Gross Body Coordination	Speed of Closure	
	Gross Body Equilibrium	Flexibility of Closure	
	Near Vision	Perceptual Speed	
	Far Vision	Spatial Orientation	
	Visual Color	Visualization	
	Discrimination	Selective Attention	
	Night Vision	Time Sharing	
	Peripheral Vision		
	Depth Perception		
	Glare Sensitivity		
	Hearing Sensitivity		
	Auditory Attention		
	Sound Localization		

Table 4.2: O*NET Activities Classification

Routine Tasks		Non-Routine Tasks			
Manual	**Cognitive**	**Manual**	**Cognitive**		
			Analytical	**Interactive/Communication**	
				Social/Emotional (Deming)	**Other**
Performing General and Physical Activities	Documenting/Recording Information	Inspecting Equipment, Structures, or Material	Evaluating Information to Determine Compliance with Standards	Establishing and Maintaining Interpersonal Relationships	Performing Administrative Activities
Handling and Moving Objects		Assisting and Caring for Others	Analyzing Data or Information	Selling or Influencing Others	Staffing Organizational Units
Controlling Machines and Processes		Operating Vehicles, Mechanized Devices, or Equipment	Interacting with Computers	Resolving Conflicts and Negotiating with Others	Communicating with Supervisors, Peers, or Subordinates
Monitor Processes, Materials, or Surroundings		Repairing and Maintaining Mechanical Equipment	Drafting, Laying Out, and Specifying Technical Devices, Parts, and Equipment	Coordinating the Work and Activities of Others	Communicating with Persons Outside Organization
Monitoring and Controlling Resources		Repairing and Maintaining Electronic Equipment	Scheduling Work and Activities		Performing for or Working Directly with the Public
			Getting Information		Developing and Building Teams
			Making Decisions and Solving Problems		Training and Teaching Others
			Thinking Creatively		Guiding, Directing, and Motivating Subordinates
			Updating and Using Relevant Knowledge		Coaching and Developing Others
			Developing Objectives and Strategies		Provide Consultation and Advice to Others
			Organizing, Planning, and Prioritizing Work		
			Identifying Objects, Actions, and Events		
			Estimating the Quantifiable Characteristics of Products, Events, or Information		
			Judging the Qualities of Things, Services, or People		
			Processing Information		
			Interpreting the Meaning of Information for Others		

Table 4.3: Sector Changes in Exports, 2002–2012

Broad Industry Group	Highest Increase		Lowest Increase		Overall Number of ISIC 3 Two Digit Industries
Agriculture	Forestry and logging	884%	Fishing and agriculture	35%	3
Mining	Coal and lignite	679%	Crude petroleum and gas	157%	4
Manufacturing (excl. Textiles)	Radio, TV and communication equipment	6,504%	Publishing, printing, and media reproduction	315%	19
Textiles	Textiles	750%	Luggage, footwear, handbags, etc.	330%	3
Services	Electricity, gas, water supply	1,455%	Other business activities	8%	4
Total Number of Industries					**34**

ISIC = International Standard Industry Classification.
Source: UNCTAD.

Technology

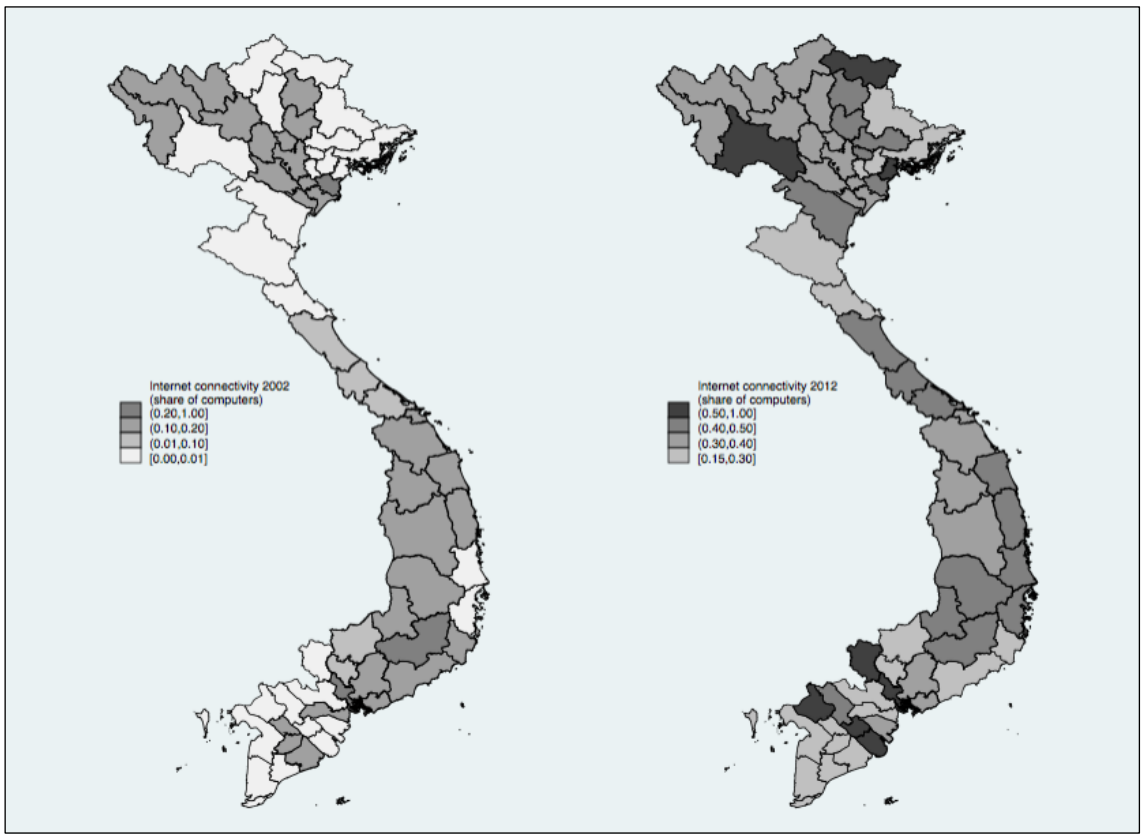
The VHLSS asks households about whether they have internet connectivity. We rely on this data to create a province-specific share of households that have access to the internet. Figure 5 presents the data on internet adoption in Viet Nam in 2002 and 2012. In 2002, on average across all provinces only 8% of households are connected to the internet. Internet use in Viet Nam increased to around 50% of the population on average across provinces. The remote northernmost province of Ha Giang is the only province where the average internet coverage is less than 1%. However, this province is also home to less than one percent of the Vietnamese population and has the lowest population density in the country. Internet use is most prevalent in Ha Noi, Da Nang, and Hai Phong cities, as well as An Giang province, where about 80% of computers are connected to the internet.

We also rely on the VHLSS to generate important province-by-time and industry-by-time control variables. Specifically, we create measures related to the share of households in the province that are among the ethnic minority, the share of households in the province in urban areas, and the province-specific age composition of the population. We also characterize the industry's educational composition of employment.

4.2 Trade Data

We match the province-by-industry employment information, the province-specific technology data, and controls to industry-specific trade data from UNCTAD's COMTRADE database. COMTRADE reports trade at the 6-digit Harmonized System (HS) product classification. We use publicly-available concordances to aggregate the 6-digit HS trade data and match to the 2-digit ISIC Revision 3 industry classification found in the VHLSS. In cases of multiple matches, we calculated the simple average. Ultimately, we arrive at 34 different industries, the same as in other papers using the VHLSS (e.g., McCaig 2011). Table 4.3 depicts the industries with the largest and smallest export changes between 2002 and 2012 by the broad industry group. While all industries have seen an increase, the largest changes were in the production of radio, television, and communication equipment.

Figure 5: Internet Coverage in Viet Nam, 2002 and 2012



Source: VHLSS, 2002 and 2012.

5. EMPIRICAL METHODOLOGY

Our goal in this paper is to uncover how technology and trade affect skills. We rely on province-specific information on access to technology and industry-specific information on exposure to foreign markets. Our work also considers the interaction between trade and technology, as trade can be a conduit for technological advancement and communications technology can serve to lower trade costs.

We begin with the following framework in mind:

$$y_{kpt} = \gamma_1\left(TRADE_{kt} * TECH_{pt}\right) + \beta_1 TRADE_{kt} + \beta_2 TECH_{pt} + \varphi_k + \varphi_p + \delta_t + \varepsilon_{kpt} \quad (1)$$

where *k* indexes the industry, *p* indexes the provincial location, and *t* indexes time.

We relate the industry-by-province occupational task-intensity (y_{kpt}), defined as the logarithm of relative use of cognitive-to-manual tasks and relative use of non-routine-to-routine tasks, separately, to the industry-, provincial-, and time-varying variables of interest. We also consider individually the levels of manual, cognitive, non-routine, and routine task intensity. In this setting, $TRADE_{kt}$ represents Vietnamese exports in industry *k* and year *t*, and $TECH_{pt}$ denotes the share of households in province *p* and year *t* with access to internet service. We are interested in both the level effects of trade and technology on skills, as well as their interactive effect on skills.

Our baseline estimation also includes industry fixed effects (φ_k) to capture time-invariant factors, such as the industry's unobserved underlying productivity or technology, province fixed effects (φ_m) to capture the province's unobserved level of development, which may influence both the workforce composition and, hence, task intensity, as well as the likelihood of access to digital technologies. Finally, we also include year-specific dummies (δ_t) to control for the average effect of Viet Nam's many policy reforms over this time period. The fact that internet access varies across provinces and over time and exports vary across industries and over time makes it possible to control for province-specific, industry-specific, and time-specific effects in this manner to identify the technology and trade shocks.

However, the trade variable in equation (1) may be endogenous due to industry-specific shocks to productivity that increase exports in industry *k* at time *t*, and coincidentally increase the skill composition of the workforce. Therefore, we follow previous work and instrument industry-specific exports from Viet Nam with the world's demand for imports in the same industry *k* and year *t*. Viet Nam's industry-by-time shocks to exporting are captured, as follows, by world import demand ($WIMPD_{it}^{VNM}$):

$$WIMPD_{it}^{VNM} = \sum_{c} w_{ic}^{2001} * IMP_{ict}$$

where IMP_{ict} denotes country *c*'s imports of product *i* (at the 4-digit HS level) minus the country's imports from Viet Nam in time *t*. We weight this import demand by Viet Nam's initial exposure to country *c* in product *i* in a pre-period 2001, $w_{ic}^{2001} = \frac{EXP_{ic}}{\sum_{ic} EXP_{ic}}$. For the purposes of our research, we then concord the HS product-level world import demand statistics to the ISIC industry classification found in the household surveys, as with the other trade data. The instrument relies on the fact that, for example, changes in the demand for fabrics in the US impact the global exposure of industries with export sales initially concentrated in fabrics sent to the US, but these same changes in import demand have no direct impact on the industry's workforce composition.

6. MAIN RESULTS

We are interested in the impact of technology and trade on skills in Viet Nam. Tables 6.1 and 6.2 present our main empirical results based on the reduced-form specifications described in the previous section.

Cognitive versus Manual Skills

Table 6.1 presents our main results for occupational abilities. The first four columns of the table report estimates from variations on equation (1) by ordinary least squares (OLS), with robust standard errors. The main technology variable is defined by the share of households with access to the internet in the province and year, and the main trade variable is the 2-digit ISIC Revision 3 exports from Viet Nam in the same year. The top panel reports results where the dependent variable is the cognitive task intensity; the middle panel reports results where the dependent variable is the manual task intensity; and the bottom panel reports the relative cognitive-to-manual task intensity. In column (1), we report coefficients for a modified version of equation (1) which includes only the key technology variable. Likewise, column (2) reports estimates for equation (1) in which we include only the key industry-time trade variable of interest. In column (3), we include both trade and technology variables. Finally, column (4)

contains our main baseline regression, as outlined in equation (1) with both the level effects of trade and technology, as well as their interactive effect on skills.

Table 6.1: Internet, Trade, and Abilities

	Cognitive Task Intensity$_{pkt}$						
Technology$_{pt}$	–0.013		–0.012	–0.034		–0.012	0.015
	(0.031)		(0.032)	(0.049)		(0.032)	(0.055)
Trade$_{kt}$		–0.006	–0.006	–0.007	0.047**	0.048**	0.054***
		(0.006)	(0.006)	(0.006)	(0.019)	(0.019)	(0.018)
Technology*Trade$_{pkt}$				0.004			–0.004
				(0.006)			(0.007)
	Manual Task Intensity$_{pkt}$						
Technology$_{pt}$	–0.017		–0.017	–0.108*		–0.018	0.087
	(0.039)		(0.040)	(0.065)		(0.042)	(0.086)
Trade$_{kt}$		0.041***	0.041***	0.037***	0.164***	0.170***	0.193***
		(0.009)	(0.009)	(0.009)	(0.030)	(0.031)	(0.031)
Technology*Trade$_{pkt}$				0.015*			–0.017
				(0.007)			(0.011)
	Cognitive/Manual Task Intensity$_{pkt}$						
Technology$_{pt}$	0.003		0.005	0.073		0.006	–0.073
	(0.043)		(0.044)	(0.084)		(0.045)	(0.097)
Trade$_{kt}$		–0.046***	–0.048***	–0.044***	–0.117***	–0.122***	–0.139***
		(0.011)	(0.011)	(0.012)	(0.033)	(0.034)	(0.032)
Technology*Trade$_{pkt}$				–0.011			0.013
				(0.010)			(0.013)
Number of Obs.	4,304	4,260	4,231	4,231	4,260	4,231	4,231
Province-Year Controls	YES	YES	YES	YES	YES	YES	YES
Industry-Year Controls	YES	YES	YES	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Province Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Instrument	NO	NO	NO	NO	YES	YES	YES

Sources: VHLSS, O*NET, UNCTAD.

We find the OLS results to be quite interesting. Technology is skill-biased in Viet Nam, and the impact of trade liberalization follows classic trade theory—that is, the low-skilled labor abundant country of Viet Nam experiences a growth in low-skilled labor-intensive tasks following liberalization. Access to the internet reduces manual task intensity, while increased trade increases the demand for manual tasks in Viet Nam. Therefore, the OLS results suggest that, though technology shifts the composition of the workforce toward skilled (cognitive) tasks, international trade serves to limit this negative effect on unskilled (manual) workers, by shifting the workforce composition toward manual workers. Interestingly, the OLS results suggest that international trade works to combat any skill-biased technology shock in Viet Nam. Increased trade by industries located in provinces with higher access to the interest relatively increase their demand for unskilled manual tasks. That is, an industry located in a province with a high adoption of the internet shifts workforce composition toward manual labor, as compared to otherwise identical industries located in provinces without access to the internet.

Table 6.2: Internet, Trade, and Activities

	Non-routine Task Intensity$_{pkt}$						
Technology$_{pt}$	–0.059		–0.060	–0.066		–0.060	0.072
	(0.037)		(0.038)	(0.062)		(0.038)	(0.079)
Trade$_{kt}$		–0.039***	–0.039***	–0.039***	0.079***	0.082***	0.111***
		(0.008)	(0.008)	(0.008)	(0.026)	(0.027)	(0.027)
Technology*Trade$_{pkt}$				0.001			–0.021**
				(0.007)			(0.011)
	Routine Task Intensity$_{pkt}$						
Technology$_{pt}$	0.012		0.010	–0.003		0.010	0.086*
	(0.022)		(0.023)	(0.039)		(0.024)	(0.050)
Trade$_{kt}$		0.005	0.006	0.005	0.060***	0.062***	0.079***
		(0.005)	(0.005)	(0.005)	(0.017)	(0.018)	(0.017)
Technology*Trade$_{pkt}$				0.002			–0.012*
				(0.005)			(0.007)
	Non-routine/Routine Task Intensity$_{pkt}$						
Technology$_{pt}$	–0.071*		–0.070*	–0.062		–0.070*	–0.015
	(0.041)		(0.041)	(0.079)		(0.041)	(0.088)
Trade$_{kt}$		–0.044***	–0.044***	–0.044***	0.019	0.020	0.033
		(0.010)	(0.011)	(0.011)	(0.029)	(0.030)	(0.029)
Technology*Trade$_{pkt}$				–0.001			–0.009
				(0.010)			(0.012)
Number of Obs.	4,304	4,260	4,231	4,231	4,260	4,231	4,231
Province-Year Controls	YES	YES	YES	YES	YES	YES	YES
Industry-Year Controls	YES	YES	YES	YES	YES	YES	YES
Industry Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Province Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Instrument	NO	NO	NO	NO	YES	YES	YES

Sources: VHLSS, O*NET, UNCTAD.

However, recall that the main trade variable may be biased due to unobserved industry-specific productivity shocks that impact both Vietnamese exports and the skill composition. The main results are slightly different when we instrument for Vietnamese exports with world import demand, as is illustrated in the final three columns of the table. The results with instrumented trade continue to support classic trade theory—increased trade in Viet Nam has an expansionary effect on employment, reporting increased demand for both cognitive and manual skills. Yet, consistent with classic trade theory, we see a larger increase in the demand for low-skilled workers performing manual tasks, shifting the composition of local labor demand to lower-skilled, manual labor. By contrast, once we instrument for trade, we now find that, on its own, technology does not alter the demand for skills in Viet Nam. Moreover, likely due to the unobserved productivity shocks that both increased employment and increased exports, we also see that when we instrument for trade, we no longer find a differential positive effect on manual skills in industries located in areas of the country with heightened access to the internet. If anything, the point estimate is negative, suggesting that manual skills decline by more in response to a trade shock in industries located in technologically-advanced areas, providing support for the idea that technology is indeed skill-biased.

Non-routine versus Routine Skills

Table 6.2 presents the same set of results for occupational activities—non-routine versus routine activities. Once again, we present results from the OLS estimation of equation (1) in the first four columns, and the IV results in the final three columns. We concentrate our analysis on the IV results, as they correct for the unobserved bias in the trade variable.

The results are qualitatively similar to the results presented in Table 6.1. Increased exposure to trade in Viet Nam is associated with a growth in the demand for labor—both non-routine tasks and routine tasks. We also notice that the impact of trade on employment is reduced in areas of the country with access to the internet. This is suggestive of the idea that technology is labor-saving in Viet Nam. Trade increases employment opportunities, but increased access to technology means employers require fewer workers to achieve the same amount of output as before.

7. CONCLUDING REMARKS AND POLICY IMPLICATIONS

Our goal in this paper is to investigate the impact of trade and technology on the demand for skill in a developing country. We explore household surveys from Viet Nam, combined with data on the task content of occupations, on industry-level exposure to international trade, and on provincial-level variation in access to information and communications technology. We assess the extent to which the adoption of digital technology and increased exposure to foreign markets affects the demand for different types of skills in the labor market, meanwhile accounting for unobserved productivity shocks associated with exporting by instrumenting for the main trade variable.

Our work also extends much of the existing literature to consider the interplay between trade and technology on labor demand. As trade can be a conduit for technological advancement and communications technology can serve to lower trade costs, we hypothesize that the two economic forces have a potentially offsetting effect on the demand for skills.

In fact, our results show that international trade works to enhance the potentially skill-biased technological change transpiring in Viet Nam. Increased exposure to trade in Viet Nam serves to expand employment opportunities, for both skilled and unskilled workers. However, increased trade by industries located in provinces with higher access to the internet relatively decrease their demand for routine and non-routine tasks. That is, an industry located in a province with a high adoption of the internet shifts workforce composition away from workers and presumably toward capital and machinery, as compared to otherwise identical industries located in provinces without access to the internet. Future research intends to explore the heterogeneity in this result across gender, age, and ethnicity to uncover which types of workers are benefiting from trade exposure and harmed by technological change.

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